BRITISH STANDARD

BS EN
12540:2000

Corrosion protection of metals — Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and copper plus nickel plus chromium

The European Standard EN 12540:2000 has the status of a British Standard

ICS 25.220.40

National foreword

This British Standard is the official English language version of EN 12540:2000. It supersedes BS 1224:1970 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee STI/33, Electrodeposited and related coating, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Corrosion protection of metals - Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and copper plus nickel plus chromium

Protection contre la corrosion des métaux – Revêtements électrolytiques de nickel, nickel plus chrome, cuivre plus nickel et cuivre plus nickel plus chrome

Korrosionsschutz von Metallen – Galvanische Nickel-Überzüge und Nickel-Chrom-Überzüge, Kupfer- Nickel-Überzüge und Kupfer-Nickel-Chrom-Überzüge

This European Standard was approved by CEN on 1 March 2000.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 262, Metallic and other inorganic coatings, the Secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2000, and conflicting national standards shall be withdrawn at the latest by October 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for nickel, nickel plus chromium, copper plus nickel and copper plus nickel plus chromium electrodeposited coatings applied to iron and steel, to zinc alloys and to copper and copper alloys to provide an attractive appearance and corrosion resistance.

The nickel and copper plus nickel coatings without chromium topcoats that are specified in this European Standard are suitable for applications in which tarnishing is prevented by rubbing or handling in service, or by the use of topcoats other than chromium. They are also suitable for those applications where tarnishing is of no importance.

NOTE: This European Standard is not intended to be used alone, but is the complement of EN 1403. The purchaser has to specify the electrodeposited coating in accordance with the designation as specified in EN 1403.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1403:1998,	*Corrosion protection of metals - Electrodeposited coatings - Method of specifying general requirements*.
EN ISO 1462,	*Metallic coatings - Coatings other than those anodic to the basis metal - Accelerated corrosion tests - Method for the evaluation of results (ISO 1462:1973)*.
EN ISO 1463,	*Metallic and oxide coatings - Measurement of coating thickness - Microcospical method (ISO 1463:1982)*.
EN ISO 2177,	*Metallic coatings - Measurement of coating thickness - Coulometric method by anodic dissolution (ISO 2177:1985)*.
EN ISO 2361,	*Electrodeposited nickel coatings on magnetic and non-magnetic substrates - Measurement of coating thickness - Magnetic method (ISO 2361:1982)*.
EN ISO 2819,	*Metallic coatings on metallic substrates - Electrodeposited and chemically deposited coatings - Review of methods available for testing adhesion (ISO 2819:1980)*.
prEN ISO 3497:1999,	*Metallic coatings - Measurement of coating thickness - X-ray spectrometric methods (ISO/DIS 3497:1998)*.
EN ISO 4541,	*Metallic and other non-organic coatings - Corrodkote corrosion test (CORR test) (ISO 4541:1978)*.
EN ISO 8401:1994,	*Metallic coatings - Review of methods of measurement of ductility (ISO 8401:1986)*.
ISO 9227,	*Corrosion tests in artificial atmospheres - Salt spray tests*.

3 Terms and definitions

For the purposes of this standard, the terms and definitions given in EN 1403 apply.

4 Information to be supplied by the purchaser

Information shall be supplied by the purchaser in accordance with EN 1403.

Additional information shall be supplied by the purchaser to identify special types of nickel and/or chromium coatings in accordance with Table 1.

5 Designation

5.1 General

In addition to the requirements specified in EN 1403 the purchaser shall select the appropriate designation according to the severity that the coating has to withstand (see Annex A).

NOTE 1: Service condition numbers are associated with typical service conditions in Table B.1.

NOTE 2: Examples of designations are given in Annex C.

5.2 Coating type

5.2.1 Types of nickel and chromium coating

The type of nickel and chromium coating shall be designated by the appropriate symbol in accordance with Table 1.

NOTE 1: Black chromium thicknesses are in the range 0,5 μm to 2 μm.

NOTE 2: Micro-cracked chromium thicknesses may vary over the range 0,3 μm to 0,8 μm depending on the process used to achieve the micro-cracked effect. With some processes approximately 0,8 μm will be required to achieve a satisfactory crack pattern, and sometimes even more. It may be produced either as a single or a double layer coating using special chromium plating solutions or by depositing regular chromium over a 1 μm to 3 μm layer of micro-cracked nickel, this being applied on top of b, s, p or d-nickel.

NOTE 3: Micro-porous chromium is often achieved by depositing chromium over a special thin nickel layer which contains inert, non-conducting particles, the special nickel layer being applied on top of b, s, p or d-nickel.

NOTE 4: There may be some loss of lustre after a period of service in the case of mp or mc chromium deposits which may be unacceptable in some applications. This tendency can be reduced by increasing the minimum chromium coating thickness to 0,5 μm in every case where micro-porous or micro-cracked chromium is specified in Tables A.1 to A.3.

Table 1 — Nickel and chromium coating types

Chemical symbol	Symbol	Properties of the coating	Possible alternatives to be decided by the purchaser with the ordering information
Ni	b	A coating in the full-bright condition	-
	p	A dull or semi-bright coating that has been mechanically polished	The type of nickel coating that has to be polished shall be specified
	s	A dull, satin or semi-bright coating that has not been polished mechanically	The type of nickel coating that shall be deposited, i.e. dull, semi-bright or “proprietary satin”[a]
	d	A double or triple layer coating (see Table D.1)	It shall be specified whether the coating shall be double or triple layered
Cr	r	A regular chromium coating (0,3 µm minimum local thickness)	-
	b	A black chromium coating (see NOTE 1 to 5.2.1)	-
	mc	A micro-cracked chromium coating that, when tested by the method described in Annex E, shall have more than 250 cracks per centimetre in any direction and form a closed network over the whole surface (see NOTE 2 to 5.2.1)	The method used to achieve micro-cracking has to be specified
	mp	A micro-porous chromium coating that, when tested by the method described in Annex E, shall contain at least 10 000 pores per square centimetre (see NOTE 3 to 5.2.1)	-

[a] Some proprietary satin nickel coatings may not meet corrosion test requirements (see Table A.1).

5.2.2 Types and thickness of copper coating

All copper coatings directly applied on iron or steel shall be plated from a cyanide solution to a thickness of 3 µm to 8 µm.

All nickel coatings on zinc alloys shall be applied over an undercoat of copper plated from a cyanide solution to a thickness of at least 8 µm.

NOTE: Where coatings of copper thicker than 10 µm are specified, the additional thicknesses are normally achieved using high levelling acid copper electroplating solutions.

6 Heat treatment

The heat treatment shall be designated in accordance with EN 1403.

NOTE 1: Heat treatment procedures and classes are specified in ISO 9587 for stress relieving before processing and in ISO 9588 for embrittlement relief after processing, but other conditions may be specified by the purchaser provided that they can be shown to be effective.

NOTE 2: Heat treatment in accordance with the recommended conditions can never guarantee complete freedom from hydrogen embrittlement and tests should be specified whenever possible. Freedom from failure of test samples will enable a degree of confidence in the procedure to be demonstrated depending on the size of the sample tested.

7 Inspection

7.1 Coating requirements

7.1.1 Appearance

Over the significant surface, the electroplated articles shall be free from clearly visible plating defects such as blisters, pits, roughness, cracks, unplated areas, stains or discolorations.

7.1.2 Thickness

See EN 1403.

The coating thickness shall be determined in accordance with 7.2.1.

In the case of double- or triple-layer nickel coatings, the total minimum local thickness of nickel shall be that specified in the designation.

7.1.3 Adhesion

The coating shall continue to adhere to the basis metal, and the coating layers shall continue to adhere to each other when submitted to the test method specified in 7.2.2.

7.1.4 Corrosion resistance

Coated articles shall be sufficiently corrosion-resistant and pore-free to pass the appropriate test specified in 7.2.3 for the particular service condition number. The performance rating shall be determined in accordance with EN ISO 1462. The minimum acceptance rating, after testing in accordance with 7.2.3, shall be a rating of 9.

7.2 Test methods

7.2.1 Measurement of minimum local thickness

The minimum local thickness shall be determined in accordance with one of the following methods: EN ISO 1463, EN ISO 2177, EN ISO 2361 and prEN ISO 3497:1999 (see Annex F).

In case of dispute, EN ISO 2177 (coulometric method) shall be used to determine the thickness of the chromium coating and of nickel coatings less than 10 μm thick. EN ISO 1463 (microscopical method) shall be used to determine the thickness of nickel coatings and undercoats of thickness 10 μm and above.

7.2.2 Burnishing test for adhesion

The requirements specified in EN ISO 2819 shall apply for this test.

7.2.3 Corrosion resistance

Corrosion resistance shall be determined in accordance with Table 2.

The requirements specified in Table 2 shall not apply to the edges of test specimens, which do not belong to the significant surface of the part (see EN 1403).

NOTE: For nickel coating without chromium topcoat, see Annex G.

Table 2 — Corrosion testing of nickel plus chromium coatings

Basis metal	Service condition	Duration of corrosion test (h)		
		CASS test (ISO 9227)	Corrodkote test (EN ISO 4541)	Acetic acid salt spray test (ISO 9227)
Steel	4	24	2 x 16	144
	3	16	16	96
	2	8	8	48
	1	-	-	8
Zinc alloy	4	24	2 x 16	144
	3	16	16	96
	2	8	8	48
	1	-	-	8
Copper or copper alloy	4	16	-	96
	3	-	-	24
	2	-	-	8
	1	-	-	-
NOTE: Dashes indicate that there is no test requirement.				

Annex A
(normative)

Correlation between service condition number and individual item block for standardized coating systems

Table A.1 — Coatings on steel or iron

Service condition number	(Partial) designation			
	Nickel coatings	Copper plus nickel coatings	Nickel + chromium coatings	Copper + nickel + chromium coatings
4			Fe//Ni40d/Crr Fe//Ni30d/Crmc Fe//Ni30d/Crmp Fe//Ni30d/Crb Fe//Ni30p/Crmc Fe//Ni30p/Crmp Fe//Ni30p/Crb	Fe//Cu20/Ni30d/Crr Fe//Cu20/Ni25d/Crmc Fe//Cu20/Ni25d/Crmp Fe//Cu20/Ni25d/Crb Fe//Cu20/Ni25p/Crmc Fe//Cu20/Ni25p/Crmp Fe//Cu20/Ni25p/Crb Fe//Cu20/Ni25b/Crmc Fe//Cu20/Ni25b/Crmp Fe//Cu20/Ni25b/Crb

continued

Table A.1— continued

Service condition number	(Partial) designation			
	Nickel coatings	Copper plus nickel coatings	Nickel + chromium coatings	Copper + nickel + chromium coatings
3	Fe//Ni30d	Fe//Cu20/Ni25d	Fe//Ni30d/Crr	Fe//Cu15/Ni25d/Crr
	Fe//Ni30p	Fe//Cu20/Ni25p	Fe//Ni25d/Crmc	Fe//Cu15/Ni20d/Crmc
	Fe//Ni30s	Fe//Cu20/Ni25s	Fe//Ni25d/Crmp	Fe//Cu15/Ni20d/Crmp
	Fe//Ni30b	Fe//Cu20/Ni25b	Fe//Ni25d/Crb	Fe//Cu15/Ni20d/Crb
			Fe//Ni30p/Crr	Fe//Cu15/Ni25p/Crr
			Fe//Ni25p/Crmc	Fe//Cu15/Ni20p/Crmc
			Fe//Ni25p/Crmp	Fe//Cu15/Ni20p/Crmp
			Fe//Ni25p/Crb	Fe//Cu15/Ni20p/Crb
			Fe//Ni40s/Crr	Fe//Cu20/Ni30s/Crr
			Fe//Ni30s/Crmc	Fe//Cu20/Ni20s/Crmc
			Fe//Ni30s/Crmp	Fe//Cu20/Ni20s/Crmp
			Fe//Ni30s/Crb	Fe//Cu20/Ni20s/Crb
			Fe//Ni40b/Crr	Fe//Cu20/Ni30b/Crr
			Fe//Ni30b/Crmc	Fe//Cu20/Ni20b/Crmc
			Fe//Ni30b/Crmp	Fe//Cu20/Ni20b/Crmp
			Fe//Ni30b/Crb	Fe//Cu20/Ni20b/Crb

continued

Table A.1— concluded

Service condition number	(Partial) designation			
	Nickel coatings	Copper plus nickel coatings	Nickel + chromium coatings	Copper + nickel + chromium coatings
2	Fe//Ni20d Fe//Ni20p Fe//Ni20s Fe//Ni20b	Fe//Cu12/Ni12p Fe//Cu12/Ni12s Fe//Cu12/Ni12b	Fe//Ni20d/Crr Fe//Ni20p/Crr Fe//Ni15p/Crmc Fe//Ni15p/Crmp Fe//Ni15p/Crb Fe//Ni20s/Crr Fe//Ni15s/Crmc Fe//Ni15s/Crmp Fe//Ni15s/Crb Fe//Ni20b/Crr Fe//NI15b/Crmc Fe//Ni15b/Crmp Fe//Ni15b/Crb	Fe//Cu20/Ni10s/Crr Fe//Cu20/Ni10s/Crmc Fe//Cu20/Ni10s/Crmp Fe//Cu20/Ni10s/Crb Fe//Cu20/Ni10b/Crr Fe//Cu20/Ni10b/Crmc Fe//Cu20/Ni10b/Crmp Fe//Cu20/Ni10b/Crb
1	Fe//Ni10p Fe//Ni10s Fe//Ni10b	Fe//Cu6/Ni6s Fe//Cu6/Ni6b	Fe//Ni10s/Crr Fe//Ni10s/Crmc Fe//Ni10s/Crmp Fe//Ni10s/Crb Fe//Ni10b/Crr Fe//Ni10b/Crmc Fe//Ni10b/Crmp Fe//Ni10b/Crb	Fe//Cu10/Ni5s/Crr Fe//Cu10/Ni5s/Crb Fe//Cu10/Ni5b/Crr Fe//Cu10/Ni5b/Crb

NOTE: In this table “s” represents dull, semi-bright and satin nickel; however some proprietary satin nickel coatings may not meet the corrosion test requirements.

Table A.2 — Coatings on zinc alloys

Service condition number	(Partial) designation		
	Nickel coatings	Nickel + Chromium coatings	Copper + Nickel + Chromium coatings
4		Zn/Cu8/Ni40d/Crr Zn/Cu8/Ni30d/Crmc Zn/Cu8/Ni30d/Crmp Zn/Cu8/Ni30d/Crb Zn/Cu8/Ni40p/Crr Zn/Cu8/Ni30p/Crmc Zn/Cu8/Ni30p/Crmp Zn/Cu8/Ni30p/Crb	Zn/Cu20/Ni30d/Crr Zn/Cu20/Ni25d/Crmc Zn/Cu20/Ni25d/Crmp Zn/Cu20/Ni25d/Crb Zn/Cu20/Ni30p/Crr Zn/Cu20/Ni25p/Crmc Zn/Cu20/Ni25p/Crmp Zn/Cu20/Ni25p/Crb Zn/Cu20/Ni30b/Crmc Zn/Cu20/Ni30b/Crmp Zn/Cu20/Ni30b/Crb

continued

Table A.2— continued

Service condition number	(Partial) designation		
	Nickel coatings	**Nickel + Chromium coatings**	**Copper + Nickel + Chromium coatings**
3	Zn/Cu20/Ni25d	Zn/Cu8/Ni30d/Crr	Zn/Cu15/Ni25d/Crr
	Zn/Cu20/Ni25p	Zn/Cu8/Ni25d/Crmc	Zn/Cu15/Ni20d/Crmc
	Zn/Cu20/Ni25s	Zn/Cu8/Ni25d/Crmp	Zn/Cu15/Ni20d/Crmp
	Zn/Cu20/Ni25b	Zn/Cu8/Ni25d/Crb	Zn/Cu15/Ni20d/Crb
		Zn/Cu8/Ni30p/Crr	Zn/Cu15/Ni25p/Crr
		Zn/Cu8/Ni25p/Crmc	Zn/Cu15/Ni20p/Crmc
		Zn/Cu8/Ni25p/Crmp	Zn/Cu15/Ni20p/Crmp
		Zn/Cu8/Ni25p/Crb	Zn/Cu15/Ni20p/Crb
		Zn/Cu8/Ni40s/Crr	Zn/Cu20/Ni30s/Crr
		Zn/Cu8/Ni30s/Crmc	Zn/Cu20/Ni20s/Crmc
		Zn/Cu8/Ni30s/Crmp	Zn/Cu20/Ni20s/Crmp
		Zn/Cu8/Ni30s/Crb	Zn/Cu20/Ni20s/Crb
		Zn/Cu8/Ni40b/Crr	Zn/Cu20/Ni30b/Crr
		Zn/Cu8/Ni30b/Crmc	Zn/Cu20/Ni20b/Crmc
		Zn/Cu8/Ni30b/Crmp	Zn/Cu20/Ni20b/Crmp
		Zn/Cu8/Ni30b/Crb	Zn/Cu20/Ni20b/Crb

continued

Table A.2— concluded

Service condition number	(Partial) designation		
	Nickel coatings	**Nickel + Chromium coatings**	**Copper + Nickel + Chromium coatings**
2	Zn/Cu8/Ni15d Zn/Cu8/Ni15p Zn/Cu8/Ni15s Zn/Cu8/Ni15b	Zn/Cu8/Ni20p/Crr Zn/Cu8/Ni15p/Crmc Zn/Cu8/Ni15p/Crmp Zn/Cu8/Ni15p/Crb Zn/Cu8/Ni20s/Crr Zn/Cu8/Ni15s/Crmc Zn/Cu8/Ni15s/Crmp Zn/Cu8/Ni15s/Crb Zn/Cu8/Ni20b/Crr Zn/Cu8/Ni15b/Crmc Zn/Cu8/Ni15b/Crmp Zn/Cu8/Ni15b/Crb	Zn/Cu20/Ni10s/Crr Zn/Cu20/Ni10s/Crmc Zn/Cu20/Ni10s/Crmp Zn/Cu20/Ni10s/Crb Zn/Cu20/Ni10b/Crr Zn/Cu20/Ni10b/Crmc Zn/Cu20/Ni10b/Crmp Zn/Cu20/Ni10b/Crb
1	Zn/Cu8/Ni10p Zn/Cu8/Ni10s Zn/Cu8/Ni10b	Zn/Cu8/Ni10s/Crr Zn/Cu8/Ni10s/Crmc Zn/Cu8/Ni10s/Crmp Zn/Cu8/Ni10s/Crb Zn/Cu8/Ni10b/Crr Zn/Cu8/Ni10b/Crmc Zn/Cu8/Ni10b/Crmp Zn/Cu8/Ni10b/Crb	Zn/Cu8/Ni10s/Crr Zn/Cu8/Ni10s/Crmc Zn/Cu8/Ni10s/Crmp Zn/Cu8/Ni10s/Crb Zn/Cu8/Ni10b/Crr Zn/Cu8/Ni10b/Crmc Zn/Cu8/Ni10b/Crmp Zn/Cu8/Ni10b/Crb
NOTE: In this table “s” represents dull, semi-bright and satin nickel; however some proprietary satin nickel coatings may not meet the corrosion test requirements.			

Table A.3 — Coatings on copper and copper alloys

Service condition number	(Partial) designation	
	Nickel coatings	Nickel + chromium coatings
4		Cu/Ni30d/Crr Cu/Ni25d/Crmc Cu/Ni25d/Crmp Cu/Ni25d/Crb Cu/Ni30p/Crr Cu/Ni25p/Crmc Cu/Ni25p/Crmp Cu/Ni25p/Crb Cu/Ni25b/Crmc Cu/Ni25b/Crmp Cu/Ni25b/Crb

continued

Table A.3 — concluded

Service condition number	(Partial) designation	
	Nickel coatings	Nickel + chromium coatings
3	Cu/Ni20d Cu/Ni20p Cu/Ni20s Cu/Ni20b	Cu/Ni20p/Crr Cu/Ni15p/Crmc Cu/Ni15p/Crmp Cu/Ni15p/Crb Cu/Ni20s/Crr Cu/Ni15s/Crmc Cu/Ni15s/Crmp Cu/Ni15s/Crb Cu/Ni20b/Crr Cu/Ni15b/Crmc Cu/Ni15b/Crmp Cu/Ni15b/Crb
2	Cu/Ni10p Cu/Ni10s Cu/Ni10b	Cu/Ni10s/Crr Cu/Ni10s/Crmc Cu/Ni10s/Crmp Cu/Ni10s/Crb Cu/Ni10b/Crr Cu/Ni10b/Crmc Cu/Ni10b/Crmp Cu/Ni10b/Crb
1	Cu/Ni5s Cu/Ni5b	Cu/Ni5s/Crr Cu/Ni5s/Crb Cu/Ni5b/Crr Cu/Ni5b/Crb

NOTE: In this table “s” represents dull, semi-bright and satin nickel; however some proprietary satin nickel coatings may not meet the corrosion test requirements.

Annex B
(informative)

Service condition number

This text is taken from EN 1403. It is reproduced here for convenience.

The service condition number expresses the severity of service conditions to be withstood by the coating, in relation to the type of atmosphere in which the coating is intended to be used. It is intended only as a help for the purchaser to decide which classification code to choose for the particular need.

The service condition numbers are associated with one or more types of atmospheres in the European Standards for each coating.

Examples of service condition numbers and associated service conditions are given in Table B.1.

Table B.1 — Examples of service conditions

Service condition number	Severity of service condition
1	Service indoors in warm dry atmospheres
2	Service indoors in places where condensation may occur
3	Service outdoors in temperate conditions
4	Service outdoors in severe corrosive conditions, eg. marine or industrial

Annex C
(informative)

Examples of designations

EXAMPLE 1

Designation of an electrodeposited coating of 20 µm copper (Cu20) plus 30 µm bright nickel (Ni30b) plus 0,3 µm micro-cracked chromium (Crmc) on iron or steel (Fe).

Electrodeposited coating EN 12540-Fe//Cu20/Ni30b/Crmc

The double solidus indicates a “missing stage”, i.e. that there has been no heat treatment.

EXAMPLE 2

Designation of an electrodeposited coating of 15 µm copper (Cu15) plus 20 µm double nickel (Ni20d) plus 0,3 µm micro-cracked chromium (Crmc) on zinc die casting (Zn).

Electrodeposited coating EN 12540-Zn/Cu15/Ni20d/Crmc

These examples do not include the standard designation of the basis metal as recommended in 5.2 of EN 1403:1998.

Annex D
(normative)

Double- and triple-layer nickel coatings

D.1 General

Table D.1 gives the requirements with which double- and triple-layer nickel coatings shall comply.

Table D.1 — Requirements for double- or triple-layer nickel coatings

Layer (type of nickel coating)	Ductility % (see D.2)	Sulfur content (mass fraction sulfur) % (see D.3)	Thickness, as a percentage of total thickness[a] %	
			Double-layer	Triple-layer
Bottom: s-type nickel	> 8	< 0,005	≥ 60	≥ 50
Middle: bright nickel (high sulfur)	-	> 0,15	–	10
Top: bright nickel	-	> 0,04 to < 0,15	≤ 40	≤ 40

[a] It is usually possible to identify the type and to determine the ratio of thicknesses of nickel layers by microcospical examination of a polished and etched section of an article prepared in accordance with EN ISO 1463.

D.2 Ductility test

The ductility shall be determined in accordance with 4.4 of EN ISO 8401:1994 (cylindrical mandrel bending).

D.3 Determination of sulfur in metals by high temperature combustion

High temperature combustion is used to determine sulfur contained in a variety of materials. High temperature (1 350 °C to 1 450 °C) combustion in the presence of oxygen oxidizes sulfur into SO_2.

Detection is most commonly provided by thermal conductivity or infrared absorption. Interfering elements are absorbed.

Commercial instruments are available for the determination of sulfur content by this method.

Annex E
(normative)

Determination of the number of discontinuities in chromium coatings

E.1 Principle

Cathodic deposition of copper under defined conditions on a representative area of a production part, whereby copper is deposited only on the underlying nickel that is exposed through discontinuities in the chromium. Assessment of the discontinuities in terms of copper nodules deposited within a given area or the number of cracks revealed in a given length.

E.2 Apparatus

Ordinary laboratory apparatus and

Plating bath, by means of which copper can be deposited cathodically onto the test piece.

The bath solution shall contain 200 g/l of copper sulfate ($CuSO_4.5H_2O$) and 20 g/l of sulfuric acid (ρ = 1,84) (H_2SO_4), and shall be maintained at a temperature of 18 °C to 24 °C throughout the determination. The cathode current density used shall be 3 A/dm².

E.3 Procedure

E.3.1 Preparation of test piece

Prepare the test piece as follows.

Mask all the edges not covered by the chromium coating with a non-conductive paint or pressure-sensitive tape, including the wire used to make contact with the cathode bar of the plating bath. Clean by immersion in a hot alkaline cleaner at a temperature not exceeding 65 °C until the surface is homogeneously wetted. Gentle scrubbing with a soft brush is helpful. Thoroughly rinse in cold running water, and then immerse for 5 s to 10 s in a sulfuric acid solution of approximately 5 % mass fraction. In cases where the test is applied several days after chromium deposition, immerse the test piece in a solution containing 10 g to 20 g of nitric acid (ρ = 1,40) per litre for 4 min at approximately 65 °C, before the copper deposition stage, to help reveal the cracks or pores.

E.3.2 Determination

Connect the test piece and the anode to the current supply before immersion. Immerse both electrodes in the plating bath (E.2) and deposit the copper cathodically on the prepared test piece with a cathode current density 3 A/dm². Use an immersion time of approximately 1 min to 5 min at a temperature of 18 °C to 24 °C. The copper will deposit only on the underlying nickel that is exposed through discontinuities (pores and cracks) in the chromium.

Carefully remove the test piece, rinse in cold and then in hot water and air-dry (do not use compressed air). Do not wipe the test piece where pores or cracks are to be counted.

Estimate the number of discontinuities in the chromium by counting the copper nodules deposited within a known area or the number of cracks in a known length of the test piece. These determinations may be carried out using either a metallurgical microscope fitted with a calibrated reticle in the eyepiece, or from microphotographs taken of a representative field of the test piece.

Annex F
(informative)

Thickness test methods for coatings

The following is a guide to the use of the thickness test methods specified in 7.2.1.

EN ISO 1463 (microscopical method) can be used to measure each nickel layer and also any undercoat of copper or copper alloy.

EN ISO 2177 (coulometric method) can be used to measure the thickness of the chromium layer, the total thickness of nickel, the thickness of a copper undercoat and the thickness of a copper alloy undercoat if the composition of the copper alloy is known.

EN ISO 2361 (magnetic method) can be used for the measurement of b, d, or s nickel on zinc alloys, copper alloys and on ferrous materials, if an appropriate calibration can be made.

prEN ISO 3497:1999 (X-ray spectrometric methods) is suitable for the measurement of the thickness of chromium and also of an undercoat prior to the electrodeposition of nickel, e.g., copper or a copper alloy.

Annex G
(informative)

Corrosion resistance of nickel coatings

The duration of each corrosion test has not been established experimentally and the times indicated are provided as guidance only.

Table G.1 — Corrosion testing of nickel coatings

Service condition number	Duration of corrosion test (h)	
	CASS test (ISO 9227)	Acetic acid salt spray test (ISO 9227)
3	16	96
2	8	24
1	4	8

Bibliography

EN ISO 3882, *Metallic and other non-organic coatings - Review of methods of measurement of thickness*.

ISO 4526, *Metallic coatings - Electroplated coatings of nickel for engineering purposes*.

ISO 6158, *Metallic coatings - Electroplated coatings of chromium for engineering purposes*.

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